

W2
AM5
S7c

259

M. PASTEUR AND PROTECTIVE MEDICINE.

BY JNO. AVERY, M. D., OF GREENVILLE, MICH., PRESIDENT OF THE STATE BOARD OF HEALTH.

[Reprinted from a Supplement of the Annual Report of the Michigan State Board of Health for 1886.]

[No. 25] 4

To know something of the life history of men who have become eminent in statecraft, in war and in science, is a common desire. Any anecdote of Bismarck, the hero of United Germany; of Gladstone, the great untitled prince of England; of Lincoln or of Grant of our own country, is eagerly sought for and is of absorbing interest. These names fill a large and brilliant space in the history of the nineteenth century. Any personal incident that reveals to us any part of their inner lives, their boyhood sports, their school-days, their playmates, their particular likes and dislikes, their habits of thought, their manner of work, their struggles for a start in life, the gradual unfolding in their minds of what is before them, their first victory no less than their final triumph, are all subjects of popular interest. These men after struggles that are the common lot of all, have written their names on many a page of their country's history where they have become household words.

Cotemporaneous with these men, there has lived and worked a quiet man whose patriotism was not less than theirs, and whose triumphs in science have been as brilliant as theirs in statesmanship and in war, and whose contributions to the general progress and welfare of mankind have not been less than theirs. If his name is less familiar to the general reader than these brilliant ones, it is because the sphere in which he has labored is less understood, but not less important, and not that he has accomplished less.

Louis Pasteur was born in 1822 of humble parents. His father, one of the great Napoleon's old soldiers, decorated on the field of battle, returned to France at the close of the wars with only his decorations to start with in life. He went to work in a tannery, and soon after married a peasant girl. Louis was their first born. With mingled pride and prophecy they were often heard to say: "We will make of him an educated man." When Louis was three years old, his father bought a small tannery in a neighboring town, to which he removed. And in the yard of his tannery until he was old enough to go to school, Louis Pasteur spent his childhood. He was first sent to the communal college, loaded down with large dictionaries for which he could have no possible use. He was very fond of his school; but he was a boy, and often missed his way to the college and brought up at the fish-pond. Besides he often ran away from school and spent his time in making portraits of his neighbors, and I have no doubt caricatures of his teachers. Some of these drawings are still preserved, and are said to be very accurate. An old lady who knew him well said a short time since, "What a pity he should have buried himself in chemistry. He has missed his vocation, for he might by this time have made his reputation as a painter." But soon Louis began to realize the great sacrifice his father was making in his behalf, and abandoned his fishing and his portrait drawing and went earnestly to work, and soon attracted the attention of the principal of the college who used to say, "He will go far. It is not for a chair in a small college like ours, we must prepare him; he must become professor in a royal college." "My little friend," he would add, "think of the great *ecole normale*." And after due preparation, to the great *ecole normale*

he went, and took with him that love for chemistry which became the passion of his life.

Here he had for instructors, M. Dumas, exact, dignified, and dealing with general principles; and M. Ballard, earnest and brilliant and delighting in the presentation of a great array of facts. Each filled young Pasteur with admiration and enthusiasm, and answered to the wants of his mind. It was now that chemistry took entire possession of the young student. To explain, to search, to question, to learn and to verify, occupied every thought and his entire time.

It was while Pasteur was yet a student in this great school that Mitcherlich, the German scientist, sent as a sort of challenge to science, the following note. "The paratartrate and the tartrate of soda and ammonia have the same chemical composition, the same crystalline form, the same angles, the same specific weight, the same double refraction, and consequently the same inclination of the optic axis. Dissolved in water their refraction is the same. But while the dissolved tartrate causes the plane of polarized light to rotate, the paratartrate exerts no such action. The nature and number of their atoms, their arrangement and their distance apart are the same in the two bodies." Pasteur could not understand how two compounds could be chemically identical and at the same time manifest this optical discrepancy, and he attacked the problem at once. This school allowed much liberty of action to its pupils, and gave them opportunity for independent research. He prepared some crystals of the tartrates and paratartrates, and upon examining them closely with the microscope and the polariscope he discovered two forms of crystals in the paratartrates. These he at first separated by hand, but it occurred to him that he ought to be able to make the separation in the laboratory. In the laboratory his experiments were not only successful but absolutely conclusive. He had discovered the left-handed tartaric acid, and solved the mystery of Mitcherlich.

Soon after this discovery he was appointed Assistant Professor of Chemistry at Strasburg, where he followed with enthusiasm the study of the tartrates. While pursuing these studies his attention was called, by a German manufacturer, to the fact that impure commercial tartrate of lime, such as is found on the sides of wine casks, when dissolved in water and exposed to the sun would ferment. Pasteur at once prepared some pure right-handed tartrate of ammonia, and found, when dissolved in water containing a little albumen, it would ferment. His solution, at first clear, became turbid, and this turbidity he found to be due to the multiplication of a microscopic organism which seemed to find its proper food in the liquid. He saw in this little organism a living ferment. He now tried the same experiment with the paratartrate of ammonia. This also fermented and deposited the same form of organisms; but under the polariscope the liquid, at first neutral, soon began to deflect the light to the left, and soon this deflection reached its maximum when fermentation ceased. The little organism, or living ferment, had decomposed or eaten up the right-handed tartrate. The liquid was now evaporated and the residue crystallized into beautiful specimens of the left-handed tartrate. And here a new fact was discovered, viz., the power of minute organisms to change or modify chemical affinity.

Thus unexpectedly did Pasteur arrive at a turn in the path he had so diligently pursued. Should he abandon the course in which his first brilliant discovery was made and pursue these "infinitely little" organisms? An incident

decided him. He was made dean of the Faculty of Science at Lille. One of the principal industries of that province was the manufacture of alcohol from beets. Partly with a view of directing attention to and creating popular interest in the new faculty, and partly because he felt there was a broad and fertile field to be traversed in pursuing these newly discovered organisms, he determined to devote a portion of his lectures to the study of fermentation. Notwithstanding the fact of the discovery of the yeast plant by Latour and Schwann some time before, the theory of fermentation at this time was, the change which takes place in all nitrogenous substances when exposed to the air. Oxygen was looked upon as the great decomposer of organized matter. Liebig added the weight of his great name to this theory. But it did not satisfy M. Pasteur. He experimented with milk and discovered the lactic ferment. And soon after, in the same substance or some of its products, he found the butyric ferment. These two organisms he found to be entirely distinct,—different in structure, in their general characteristics, and in their habits. The lactic ferment required for its existence and multiplication, free oxygen or air; while the butyric ferment died when exposed to the atmosphere. These two ferments may serve as types of the two great classes into which Pasteur divided micro-organisms, viz: Those that require air to live; and those that can live without air—*aerobies* and *anaerobies*.

The close resemblance of the action of the butyric ferment to the phenomenon of putrefaction led Pasteur to investigate the latter, and he was soon able to demonstrate that the special fermentation known as putrefaction is caused by a living organism belonging to the same class as the butyric ferment.

The manufacture of vinegar from wine was another large industry where Pasteur resided. He had witnessed the slow and tedious process of conversion, and becoming interested, began to investigate and soon discovered the acetic acid ferment—the “*mycoderma aceti*.”

Without further extending the list, we have now as special ferments—the yeast plant,—not however discovered by Pasteur, but its true function assigned to it, by him,—the lactic acid ferment, the butyric ferment, the special ferment of putrefaction, and the acetic acid ferment. And it is curious to watch their behavior. Their office seems to be to decompose, to change and to destroy so far as destruction is possible.

The yeast plant sets up in business as a manufacturer of alcohol wherever it can find a good location, and for a time does a thriving business. But soon along comes the little *mycoderma aceti*, and like a true temperance worker, changes the alcohol into acetic acid or vinegar. The lactic ferment sours the milk, the butyric makes it rancid; and perhaps somewhere during this change tyrotoxicon or cheese-poison is developed, whether by special germs or not remains to be discovered. The *mycoderma vini* (omitted from the list) changes the expressed juice of the grape into wine; the *mycodema aceti* sours the wine. And then another organism of the nature of the butyric ferment spoils the vinegar. By the way, it will be noticed that these little *mycoderma aceti* are not exactly prohibitionists, but true temperance reformers. They permit the manufacture of alcohol and wine and then destroy them, or rather convert them to their own use.

Having demonstrated the existence and office of these germs, it did not escape M. Pasteur to inquire into their origin. Spontaneous generation was the generally accepted theory at this time, and against the advice of friends,

he closed with the question at once and was soon able to demonstrate to the scientific world that spontaneous generation was a myth, although it had at the time such able defenders as Pouchet and Dr. Bastian.

About this time, 1865, a disease which had for some time prevailed among the silk-worms of France, threatened the destruction of the silk industry of that country. The venerable M. Dumas was appointed at the head of a commission to investigate the cause of the disease, and if possible, to suggest a remedy. He prevailed upon his pupil, M. Pasteur, to undertake the investigation. At this time he had never seen a silk-worm. He hesitated. But the calamity was appalling, and M. Dumas persistent, and in June, 1865, Pasteur went to the scene of the epidemic, in the south of France. On the very day of his arrival he had found and shown to others the living corpuscles in the blood of the worms. His knowledge of the work of the living ferments prepared his mind to see in these corpuscles the germs of the disease. He followed them through all the phases of the insect's life—in the eggs, in the worm, in the chrysalis, and in the moth. He found that these germs might be present in the eggs and in the worms and escape detection; but in the moths they were so developed as to be easily discovered. He pounded a diseased worm in a mortar, and adding a little water, applied the mixture to leaves and gave them to healthy worms to eat. These worms were soon taken sick with the same disease. A single meal on leaves spread with this corpusculous matter was sufficient to infect the worms. The disease was then certainly contagious. It was communicated by direct contact, by a scratch from the claws of a diseased worm, by feeding on leaves over which a diseased worm had crawled, and by the medium of an infected atmosphere. "It was no hypothetical medium, no problematic pythogenic gas that killed the worms. It was a living organism."

The remedy was plain to a man who was in the habit of applying science to practical things. Separate the healthy from the diseased worms, give them pure air to live in and clean, fresh leaves to eat, and use only the eggs from healthy moths. And thus was the silk industry restored to France and to the world—for the disease had already spread into Spain, Portugal, Italy, and Austria.

The different modes by which communicable diseases are spread among animals and human population are well illustrated by Pasteur's treatment of the silk-worm. And this investigation prepared him for the great work of his life—the development of the theory of the parasitic origin of communicable diseases. At the conclusion of his studies on beer, which followed close upon those of the silk-worm, Pasteur remarked that the etiology of contagious diseases is on the eve of having unexpected light shed upon it.

In 1850 Drs. Davaine and Rayer found in the blood of animals dying from splenic fever, "little thread like bodies about twice the length of blood corpuscles."

Pasteur's mind, already filled with knowledge of the work of the "infinitely little" things, prepared him to see in these "little bodies" the germs of the fearful disease which at this time was decimating the herds of all Europe. He undertook the demonstration of that fact. He put a drop of splenic fever blood into sterilized yeast water. In a few hours it swarmed with myriads of bacteria. A drop of this first cultivation he put into a second flask containing the same kind of liquid and the bacteria multiplied as before. This process he repeated fifteen or twenty times, and by this means freed the initial drop

of blood from any substance it might have carried with it. And now, if a drop of this last cultivation is injected under the skin of a rabbit or a sheep the animal dies with all the symptoms of idiopathic splenic fever. The little "thread-like bodies," discovered by Davaine and Rayer fifteen years before, are proved to be the germs of this terrible malady. Now for the remedy. Though not a physician, Pasteur had not failed to note that most virulent and communicable diseases are non-recurrent. He had studied the phenomena of vaccination.

Here an artificial and benign form of a similar disease seems to exhaust the capabilities of the system to contract small-pox. The soil has been exhausted by a parasite less vigorous and destructive than the really virulent one. Is there not a vaccine for each of these virulent diseases? The virulence of small-pox is modified by passing through an animal and becomes a vaccine. May not the virus of any of the communicable diseases be so attenuated or weakened as to become benign and a true vaccine to protect against itself in its most malignant form?

In his cultivation of the microbe of fowl cholera he had observed that the one hundredth cultivation was as deadly as the first, provided the cultivations were made in quick succession. But if the cultivation is not passed on to the following one, until several days or weeks elapse, the contagium becomes weakened in proportion to the time intervening between the cultivations. If ten or twenty birds are inoculated with the fiftieth or one-hundredth cultivation, made in quick succession, all perish in twenty-four or forty-eight hours. But if the same number of birds are inoculated with the same cultivation after it has remained in its flask well stoppered with cotton-wool for three months, none will die, but all will be sick for two or three days, and when fully recovered, if re-inoculated with the most virulent virus, capable of killing its one hundred per cent, they will, perhaps, be slightly ill, but none will die, proving beyond question that this virus can be so modified as to protect against itself.

With this experience he approached the cultivation of the deadly microbe of splenic fever. But he soon found the behavior of this microbe under cultivation very different from that of the cholera microbe. The splenic fever germs appear at first in the blood, in transparent filaments more or less divided into segments. But under cultivation in the same culture fluid and at the same temperature used for the cholera bacillus, instead of continuing this mode of multiplication spores formed along the filament; the filament soon became absorbed and all cohesion between the spores lost. In this condition the virus will remain for years exposed to the air, retaining all its virulence and ready to strike down the first unfortunate animal with which it comes in contact. How can this wild microbe be tamed and made to subserve a beneficent purpose was the problem, the solution of which Pasteur undertook.

For days and weeks the experiments went on. Pasteur became more and more absorbed, and at times was heard to repeat to himself, "If one could arrive at that—if the fact of the attenuation of the microbe of fowl cholera proved not to be an isolated one." But when spoken to, his reply was, "I can tell you nothing; I dare not express what I hope." His daughter used to say, "He had the face of an approaching discovery." At length he came from his laboratory with tears in his eyes and triumph in his face. He embraced his family and all who came within his reach, and, loyal to France, as he is and always was, exclaimed: "I should never console myself if a discovery such as my assistants and myself have just made were not a French discovery." He

had tamed the wild microbe and compelled it to do his bidding. Cultivated in a temperature two or three degrees lower than that required for the cholera microbe its behavior is similar—the spores are prevented—it multiplies by division, and becomes weakened by exposure to the air, and in this way becomes a vaccine for itself. In February, 1881, Pasteur, in his own name and that of his associates, communicated this great discovery to the academy of science. It was received with patriotic pride and joy. But there were some who doubted, and said, “There is a little romance in all this. It reminds one of what the alchemist of Lasarge did to the demons which annoyed him. He shut them up in little bottles, well stoppered, and so kept them imprisoned and inoffensive.” Pasteur had, indeed, captured and imprisoned a whole world of demons in these little microbes, and set them to destroying each other.

Hardly had the journals published this discovery when the president of the agricultural society at Melun came to invite him to make a public trial of splenic fever vaccination. Pasteur accepted, and an agreement was entered into between him and the society by which fifty sheep and ten cows were to be placed at his disposal. Twenty-five of the sheep and six of the cows were to be twice inoculated with attenuated virus at an interval of twelve or fifteen days.

On the fifth day of May, 1881, twenty-four of the sheep and a goat (the goat having been substituted for one of the sheep) were inoculated with five drops of attenuated splenic virus by means of a hypodermic syringe. Six cows were also inoculated. May 17, twelve days later, these thirty-one animals were reinoculated with a stronger virus. On May 31 all the fifty animals, vaccinated and unvaccinated, were inoculated with a very virulent splenic fever virus. A very large and distinguished assemblage of persons were present on this occasion—scientists, senators, general councillors, journalists, physicians, veterinary surgeons and farmers—those who believed and those who doubted. Many of his friends were alarmed and said, “Take care; you are advancing without a possibility of being able to retreat.” No higher courage was ever exhibited by living man than by Pasteur on this memorable day. “I have full confidence,” was his calm reply. “The twenty-five unvaccinated sheep will die—the four unvaccinated cows will either die or be very ill; while the vaccinated animals will resist this virulent virus. I shall kill and I shall save.” They adjourned to meet at the same place in forty-eight hours. On re-assembling at the appointed time, a shout of admiration went up. Pasteur seemed the only calm man in the assemblage. Twenty-one of the unvaccinated sheep were dead, two were dying and the other, already smitten, was sure to die that night. The four unvaccinated cows were very ill; the fever was intense, and they had no longer strength to feed. The goat was dead; while all the other vaccinated animals were well and quietly feeding in the field.

The surgeons examined the dead and felt the living. “Well,” said M. Bouley, the most eminent of the veterinarians, “there remains nothing for you to do but to bow before the master, and to exclaim, ‘I see, I know, I believe, I am undeceived.’” Before the close of the year 1881, Pasteur had vaccinated 33,946 animals. In 1882 the number amounted to 399,102, including 47,000 oxen and 2,000 horses. In 1883, 100,000 were added to the list. In 1881 it was the common practice of farmers to vaccinate one-half of their herds and leave the other half unprotected. It was found at the close of the year that the loss in the protected sheep was ten times less than in the unprotected, being 1 in 740 as against 1 in 78. In cows and oxen it was fourteen times less, being 1 in 1,254 against 1 in 88. In 1883 the same ratio of losses between the vaccinated

and unvaccinated was maintained, saving to France, in her herds alone, more than 5,000,000 francs annually. And this saving was not confined to France. Germany, Austria, Italy and Russia shared alike in the benefits of this discovery.

In pursuing his investigations of the splenic fever disease, Pasteur made some curious and interesting discoveries which are of practical value to sanitarians and all who are interested in preventing the spread of communicable diseases. After having reduced the microbes of splenic fever to a point where they were no longer harmful to animals inoculated with them, he sought to restore their lost virulence and to make them capable of living and multiplying again in the bodies of animals. He found that an attenuated virus that could cause no harm to a guinea pig, of a year, or a month, or even a week old, would kill one just born. The weakened microbe could multiply itself in the blood of one so young; and a few drops of this pig's blood would kill one still older, and so on until the full virulence of the microbe was restored. The same was true of the microbe of fowl cholera. When it had become so attenuated as to have no effect upon fowls, he restored its virulence by inoculating successively canaries, sparrows, black-birds and young chickens, until it became of sufficient power to kill full-grown fowls. Exposed to the air, these germs become weakened, or take the form of spores, in which condition they will remain viable for years, and float in the air as minute particles of dust, until they find lodgment in the proper media for their development and multiplication.

What is true of these germs may also be true of the germs of diphtheria, scarlet fever, small-pox, typhoid fever, and other communicable diseases. In localities where these diseases have prevailed as epidemics, is it not quite possible their attenuated and viable germs are constantly floating in the air, ready to resume their active form whenever and wherever the conditions of climate, of poverty, of wretchedness, of filth, and of bad air present themselves? May they not also prove harmless to the healthy, well-fed, well-clothed, well-housed child, full of animal life, and constantly living and sleeping in pure air; while they may find in the poor child, enfeebled by hunger and exposure, and constantly living and sleeping in a vitiated atmosphere, a suitable place for their development and return to virulence. The lesson to be learned from all this is the necessity for the absolute destruction of the last germ in every case of this class of diseases, the maintenance of the highest possible degree of health, by right living, clean and wholesome surroundings, and the use of pure air at all times.

HYDROPHOBIA.

In 1880, Pasteur took up the investigation of that mysterious and fearful disease, rabies, generally known as hydrophobia. A child having died in Trousseau hospital with it, he secured some saliva from the mouth of the dead child, and inoculated two rabbits with it. In less than thirty-six hours the rabbits were dead. Saliva from these rabbits killed others in about the same time. He examined the blood and saliva of the rabbits and found a special microbe, easily cultivated, and the successive cultures of which killed other rabbits. These rabbits died within thirty-six hours after inoculation. The period of incubation for rabies is from thirty to forty days. The rabbits then died before the rabic virus had time to affect them—not of rabies but of another disease produced by a micro-organism found in the saliva of rabid animals.

He attenuated the microbes of this new disease, and used it successfully as a vaccine for itself, but all this threw no light on the disease he started out to investigate.

He next inoculated some rabbits and dogs with bits of brain substance taken from a dog that had died of rabies. After the usual period of incubation, hydrophobia developed in all the rabbits and dogs. Other rabbits and dogs inoculated with bits of brain or spinal cord from these dead animals, died after the usual period of incubation.

He had now found the real seat of the disease and the true rabic virus unmixed with another poison. Regarding now the brain or nerve center as the seat of the disease, he conceived the idea of inoculating animals directly upon the brain with rabid brain matter, in order if possible to shorten the period of incubation. He succeeded in inoculating several dogs in this way, and the result was to shorten the incubation period by ten days. Remembering his experiments and their results, with the microbes of splenic fever and fowl cholera, how passing these microbes through a succession of animals and birds of one class increased their virulence as to certain other classes, he began experimenting with rabbits, using portions of a spinal cord from a rabid dog for transmitting the disease. By this experiment he found the period of incubation shortened and the virulence of the virus increased. And when he had passed it through a succession of twenty-five rabbits, he found the period of incubation reduced from fifteen to eight days and its intensity proportionately increased. Continued through twenty-five other rabbits the period was reduced to seven days. Passing it along through forty other animals, he found evidence of a shorter period and of increasing virulence in the spinal cord of the last rabbit used after death for inoculating other animals. It is curious to note that similar experiments conducted on a series of monkeys show a constant decrease in the virulence of the rabid virus, so that after passing through twenty monkeys it is incapable of producing rabies in dogs, and that dogs inoculated with this weakened virus were rendered refractory to the stronger virus from the rabbits—that is were protected against rabies. The fresh spinal cord of a rabbit that has died of rabies is very virulent; but by exposure to dry air it becomes less and less so the longer it is kept, until its virulence is lost. Thus he has two ways of attenuating the virus of rabies—the one by cultivation in monkeys—the other by exposing the rabid cord of dead rabbits to dry air. So it is possible to have at all times at his disposal a cord of a very low degree of virulence and of all degrees leading up to the most active, such as will produce rabies in seven days.

After satisfying himself by repeated experiments of the efficacy of inoculation with the weakened virus to protect dogs against rabies, Pasteur asked the Minister of Public Instruction to appoint a commission to inquire into the results obtained by him. The commission was composed of some of the ablest physiologists of France. And in the report they submitted, they say, "That of the twenty-three dogs treated all escaped rabies." Pasteur continued his experiments until he had "rendered fifty dogs of all ages and races refractory to (or protected against) rabies without one failure." He used in these experiments the cords of rabbits affected with rabies of great virulence and capable of producing the disease within an incubation period of eight days. On the first day he used a cord that had been kept ten days, on the second one that had been kept nine days, on the third one of eight days; and so on until the tenth day, when he used one kept for only one day, and capable of producing rabies in an unprotected dog in eight days.

Fortified by these experiments, Pasteur felt justified in applying his treatment to human beings who had incurred the risk of hydrophobia.

He had not long to wait an opportunity. The period of incubation in persons bitten by rabid animals being from four to five weeks, he hoped to overtake the slowly acting virus, by using one of greater activity and increasing strength, and thus gradually render the system refractory to the virus introduced by the bite.

On July 6, 1885, Dr. Weber, of Alsace, sent to Pasteur, Joseph Meister, a child bitten a few days before by a mad dog on the hands, legs and thighs, fourteen places in all. He was considered by eminent physicians almost certain to die of hydrophobia. On that day he inoculated the child with a fragment of a rabid spinal cord from a rabbit which had died fifteen days before, the cord having been kept that length of time in dry air; in the morning of the 7th of July, with a cord fourteen days' old, and in the evening with one twelve days' old; in the morning of the 8th day of July, with a cord of eleven days' old, and in the evening with one of nine days'. From this time on the child was inoculated once daily with a cord newer than the one last used, until the 16th day of July, when one of one day old was used. The last cord used was very virulent, and rabbits inoculated with it on that day developed the disease in seven days, and healthy dogs in ten days. Joseph Meister passed unharmed through the terrible ordeal, and at last advices—sixteen months after—was in perfect health.

If we admit the possibility that he might not have contracted hydrophobia from the bites, we are still confronted by the important fact that he resisted inoculation with a rabid virus of sufficient strength to kill a large sized dog in ten days.

Since that memorable July 6, 1885, Pasteur has been very busy, and according to the last report, made the 1st of the present month, he has treated 2,140 persons bitten by rabid dogs and wolves, and lost but twelve.

The last analysis of cases treated by Pasteur, made public by Dr. Gruncher, his assistant, on June 10 last, deals with 1,335 persons exposed to rabies from bites of rabid animals. All cases treated after the 23d of April, the final results of which were then in doubt, were omitted from the list. Those treated prior to that time the doctor divides into three classes:

1. Those bitten by dogs proved to be mad, ninety-six cases and one death, 1.04 per hundred.

2. Those bitten by dogs *certified* to be rabid by the veterinary surgeons of the locality, six hundred and forty-four persons treated and three deaths, a mortality of one-half of one per cent, or 5 per 1,000.

3. Those bitten by dogs which ran off and were not seen again. Of these no account is taken.

In the first two classes we have 740 persons treated, with four deaths, giving in round numbers an average of $7\frac{1}{2}$ per 1,000.

Le Blanc places the average number of deaths in persons bitten by dogs certified to be rabid, at 16 per 100. Other authorities place it as high as 25 per 100.

Taking the lower estimate, there should have died among Pasteur's 740 patients no less than 118, but instead we have only 4, a death rate of one-half of one per cent in place of 16 per cent. In other words Pasteur has saved from a terrible death 114 persons in the nine months for which statistics are given.

In addition to these 740 patients, he has treated 48 persons bitten by rabid wolves, and lost seven, or 14 per cent.

The average number of deaths from the bite of rabid wolves, according to LeBlanc, is 82 per 100. Another authority places it at 67 per 100. According to the lower estimate, 33 of his wolf-bitten patients should have died; but instead, we have only seven deaths, a saving of twenty-six other lives.

Pasteur is still experimenting, and no doubt improving his method of treatment. He now makes but ten inoculations, instead of fifteen; one each day, beginning with a cord fourteen days old, and ending with one five days old. He may, and probably does vary his treatment of individual cases according to the number and severity of the wounds, and the length of time intervening before treatment is commenced.

In his investigation of rabies, Pasteur has evidently proceeded on the theory that it is due to a special micro-organism. Whether he has actually discovered the microbe or not, he has not told us. His assistant, M. Roux, makes a statement which would seem to imply that he has; but Pasteur himself never proclaims his guesses. He makes public only his discoveries, and the world is benefited thereby.